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DUCTILITY OF COMPOSITE STEEL/CONCRETE MEMBERS INCORPORATING RECYCLED RUBBER MATERIALS

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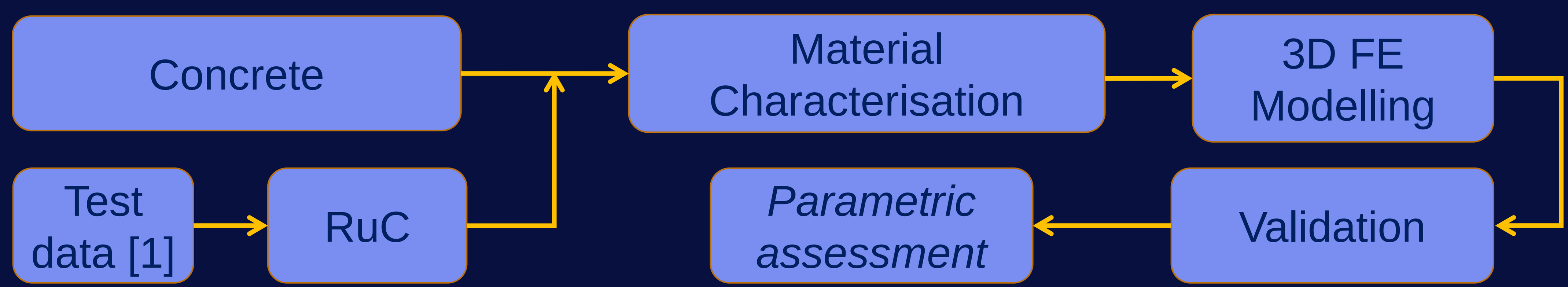
INTRODUCTION

Nowadays, the disposal of rubber materials has become a fundamental environmental issue encouraging the development of several applications involving the use of rubber, such as aggregate replacement in concrete mixture: this innovative material is called 'rubberized concrete' (RuC). As acknowledged, the addition of rubber results in a ductility improvement as well as an important strength reduction proportional to the volume of aggregate replaced, which makes this material under confinement suitable for seismic applications.

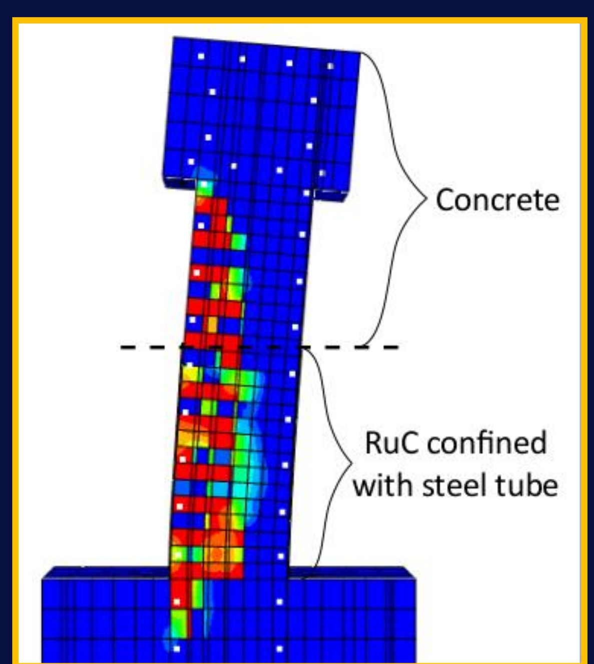
This study uses the full characterisation of the material proposed to assess the ductility and the effectiveness of composite steel/concrete solutions in columns for seismic purposes by means of Non Linear Finite Element Analysis (NLFEA).

NUMERICAL MODELLING

NLFEA has been carried out using the ABAQUS 6.14 software for numerical validation of past experimental tests.



PARAMETRIC STUDY



Seismic conditions have been reproduced statically by applying a constant vertical load and a displacement-controlled monotonic horizontal load [1]. The main reason behind the use of the steel tube on the half bottom of the column is that the confinement action can compensate for the strength loss due to rubber replacement. Additionally, steel tube confiment in the plastic hinge region produces some enhancement in ductility.

The parameters directly investigated in the numerical study are: normalised axial load (n_v), volumetric replacement ratio of the aggregate (ρ_{rv}) and relative tube thickness (t/D).

ACKNOWLEDGEMENTS

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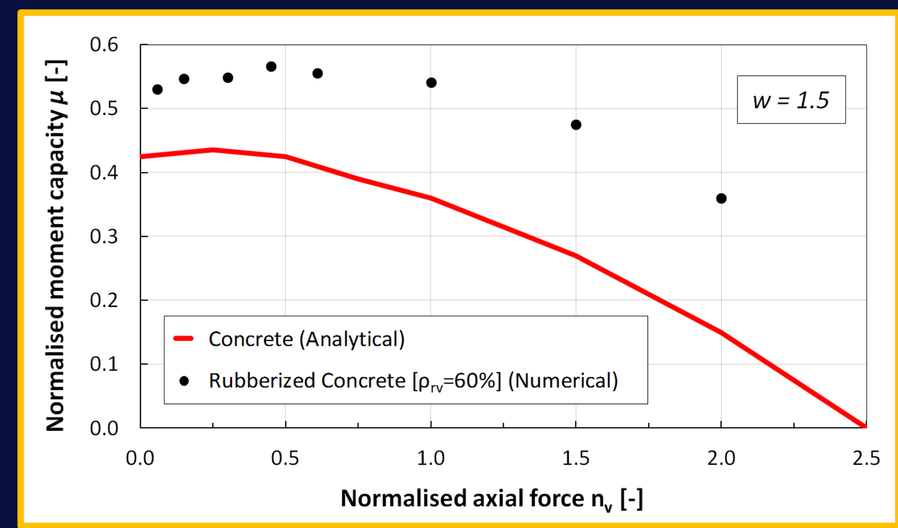
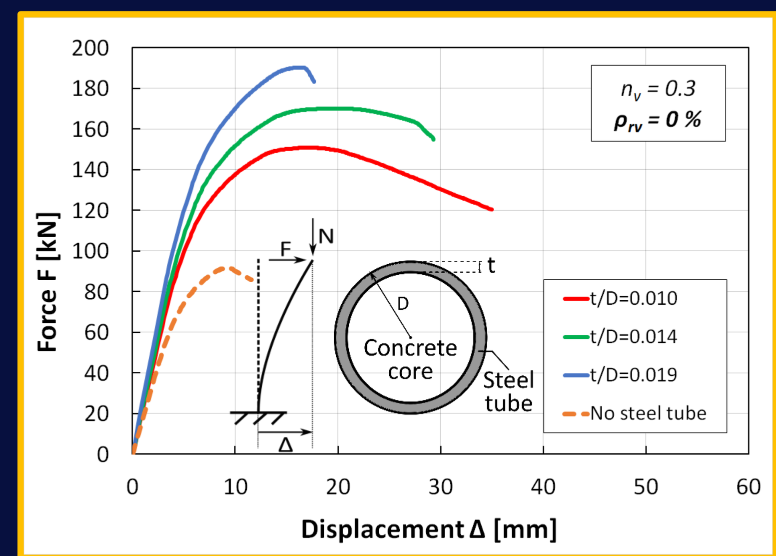
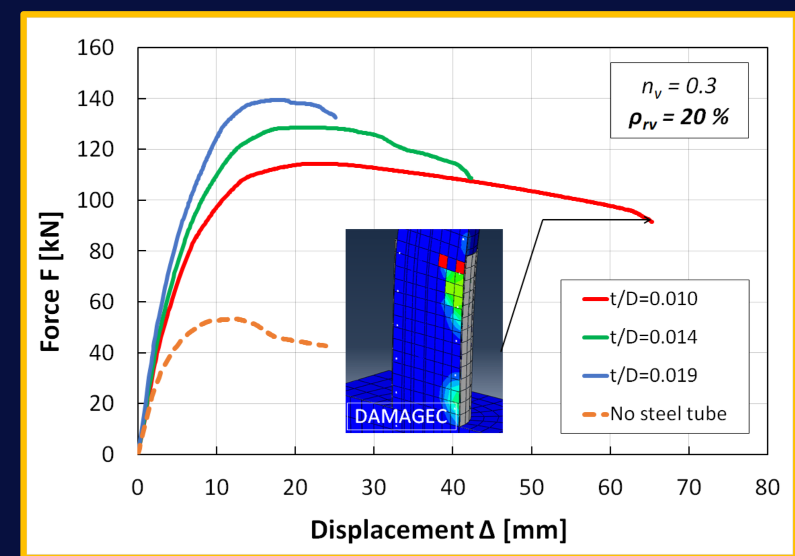
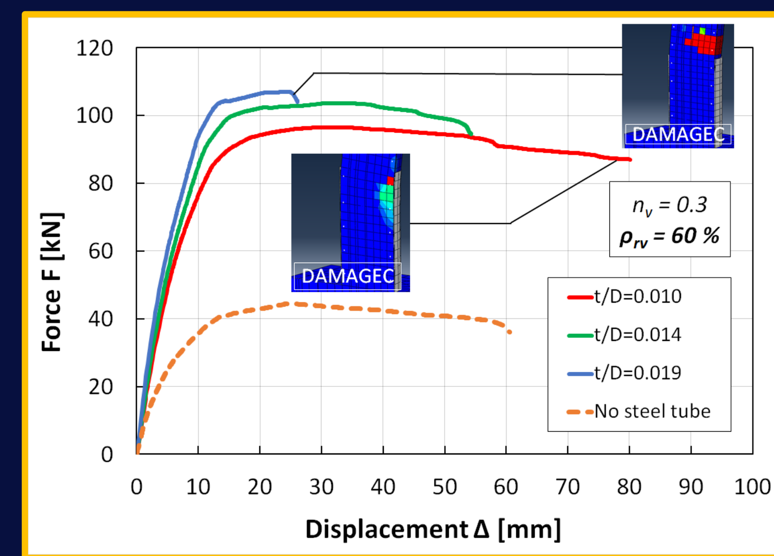
ANALYTICAL ASSESSMENT OF THE RESULTS AND DESIGN RECOMMENDATION

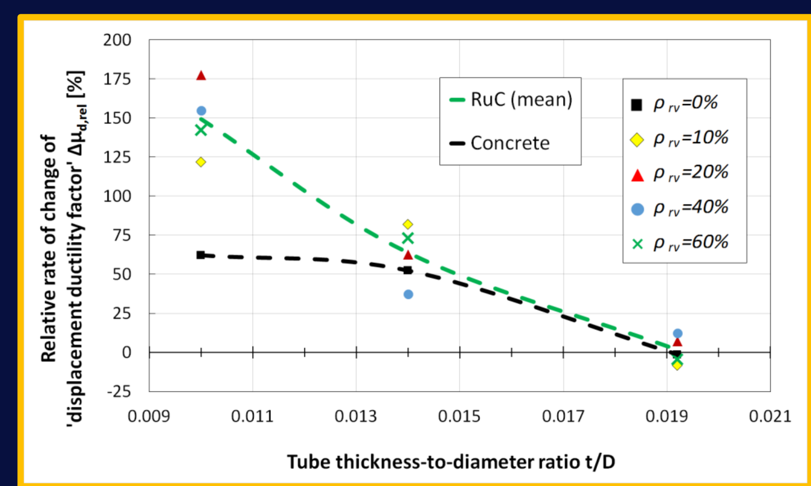


Unconfined RuC columns with ρ_{rv}=60% present larger $\mu - n_v$ domain compared to an equivalent low strength concrete [2]. Conversely, there is a significant capacity reduction which is fully covered by the addition of the steel tube. While at low values of thickness, the column exhibits high ductility due to the contribution of the RuC core; the use of a stiffer tube produces the occurrence of concrete crushing at the mid-height ('weak section').









An analytical expression of the equivalent 'Curvature ductility factor' [3] has been proposed as a modified value of the corresponding RC column ductility $\mu_{\Phi,0}$:

$$\begin{cases} \mu_{\Phi,comp} = (\mu_{\Phi,0}+1)\exp\left[\eta\left(0.02-\frac{t}{D}\right)\right]-1 & ,0.01 \le t/D \le 0.02 \\ \eta = 0.0011\rho_{rv}^3 - 0.1228\rho_{rv}^2 + 3.986\rho_{rv} + 56.605 & ,\rho_{rv} \le 60\% \end{cases}$$

CONCLUSIONS

- Replacement of mineral aggregates with rubber improves the ductility of the column and reduces its capacity
- Steel tube fully covers the flexural capacity loss due to the rubber addition
- At low values of tube thickness (0.01), the curvature ductility increases by more than *130%* for high rubber content *(20%≤ ρ_{rv} ≤ 60%)*
- For seismic design purposes, normalised tube thickness (t/D) should be limited to 0.02 since thicker tubes may produce failure at composite-to-concrete interface

REFERENCE

[1] Bompa, D.V., & Elghazouli, A. Y. (2016). D2.5 test report on medium and large scale tests - draft version. Test report. Imperial College London.
[2] Smolcic, Z., & Grandic, D. (2012). Interaction diagrams for reinforced concrete circular cross-section. Gradjevinar, 64 (1), 23-31.
[3] BSI. (2004). *Eurocode 8:* Design of structures for earthquake resistance. London, BSI.